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C. F. Brackett



Philip Luther Kling.
May, 1936.

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AN
ELEMENTARY MANUAL
OF
QUALITATIVE CHEMICAL ANALYSIS.

BY
MAURICE PERKINS,
NOTT PROFESSOR OF ANALYTICAL CHEMISTRY IN UNION COLLEGE.

NEW YORK:
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1867.

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In the Clerk's Office of the District Court of the United States for the Southern District of
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THE NEW YORK PRINTING COMPANY,
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NEW YORK.

THIS LITTLE MANUAL
Is Inscribed
AS A
TOKEN OF AFFECTION AND RESPECT
TO MY
FRIEND AND TEACHER,
DR. SAMUEL ST. JOHN.

BUHR/sci
Gift
08/05/05

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ADVERTISEMENT.

THE students in the Engineering Department of Union College, and a small division of the undergraduates, are required to spend a few hours during two terms of the senior year in the laboratory.

The design of this arrangement is to give them a greater familiarity with the facts and laws of Chemistry than is possible in the exercise of recitation alone, and, at the same time, to instruct them in the methods of analysing the more frequently occurring inorganic compounds.

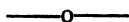
The time allotted to this exercise is too short for the study of the reactions of all the elements, and of those selected, the number of reactions admitted is limited by the condition that some hours must be employed in actual analysis.

The course taken has been to select from Professor Johnson's excellent edition of Fresenius, for each of the more commonly occurring metals, acids, and radicals, three or four of the most characteristic reactions, to write these with a system of analysis upon the black-board, indicating the chemical changes by the appropriate symbols, and to require each student to copy the whole.

The success that has attended this method of instruction and the suggestions of several chemical friends, themselves teachers, have induced the publication of this little manual, in which the system pursued is given in the same brief form as presented to the class.

The writer gratefully acknowledges his obligations to his friend and assistant, Mr. Charles A. Schaeffer, of whose suggestions he has frequently availed himself.

INTRODUCTORY.



IN the analysis of bodies, various methods are employed to bring each element into one or more familiar forms, either by combining it with another element, or by setting it entirely free, and for this purpose use is made of various reagents, both in a solid and liquid form.

When the substance to be analysed is in solution, by adding to it a few drops of some known reagent, an insoluble compound is separated. This is called a *precipitate*, and the action itself *precipitation*. Each precipitate, or group of precipitates, has its peculiar physical properties, as form, color, etc. When it is curdy, it is called caseous, jelly-like, gelatinous; when separating in flakes, flocculent. Sometimes the precipitate is crystalline and separates slowly, the faces of the crystals reflecting the light as they sink to the bottom; but more frequently it is so finely divided as to appear amorphous.

Generally the substance separated settles to the bottom of the fluid, but sometimes it passes off in the form of a gas, as ammonia, etc.

Precipitation is often accelerated by heating the fluid, or by agitation.

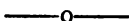
The precipitate is separated from the fluid by filtration. A disk of unsized paper is folded into a conical form, and placed in a funnel supported on a stand. The paper is first moistened with a little distilled water, and the mixture poured upon it ; the clear fluid passes into the vessel set below, while the precipitate remains on the paper. To free the precipitate from all soluble impurities, it is washed by pouring distilled water over it, until a drop from the point of the funnel leaves no residue upon platinum foil.

The elements, or their compounds, are classified according to their *Group Reactions*, and distinguished from each other by their *Special Reactions*. The same reaction may be at once a group and a special reaction.

There are also negative and positive reactions : the first, when the addition of a reagent causes no apparent change, thus proving the absence of the element sought ; and the second, where a change occurs, thus indicating the presence of the element.

The student should now proceed to make a careful study of each of the elements or compounds, which are classified according to their group reactions. The interchanges between the elements, as indicated by the symbols, should be carefully studied.

METALS.



Section 1.

FIRST GROUP.

Potassium, K. Sodium, Na. Ammonium, Am.

All sulphates, nitrates, carbonates, chlorids, cyanids, and other compounds of this group, are soluble in water. (To obtain immediate or satisfactory precipitates the solutions must be concentrated.)

Section 2.

POTASSIUM, K.

Proto-compounds of Potassium, give with *Tartaric Acid*, a white crystalline precipitate of acid TARTRATE OF POTASSA.



None of the compounds of Potassium are volatilized† at a low red heat, when heated upon platinum foil in the

* Instead of writing out the whole formula of Tartaric Acid, $C_8H_6O_{10}2HO$, it is abbreviated thus, $\bar{T},2HO$.

† A few drops of the solution, or a small piece of the solid, is placed upon a piece of platina foil about an inch square, one end of which is held by a small pair of tweezers, and then heated in the flame of the spirit-lamp.

flame. Heated upon a wire,* the compounds of Potassium colour the flame *violet*, which, when viewed through a piece of blue glass, appears red.

Section 3.

SODIUM, Na.

Proto-compounds of Sodium, give with *Tartaric Acid*, no precipitate, the acid TARTRATE formed being very soluble.

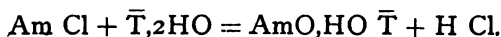
Compounds of Sodium are *not volatilized* at a low red heat.

Compounds of Sodium colour the flame *yellow*; when viewed through blue glass, no flame is seen, the yellow ray not passing through the glass.

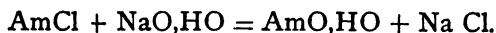
Section 4.

AMMONIUM, Am or NH₄.

Proto-compounds of Ammonium, give with *Tartaric Acid*, a white precipitate of acid TARTRATE OF AMMONIA.



When a *Hydrate of Potassa, Soda, Baryta, or Lime*, is added to a proto-compound of Ammonium, and the mixture heated, HYDRATE OF AMMONIA is given off, which can be recognised by the smell.



Compounds of Ammonium are easily *volatilized*.

* A piece of platinum wire with a small hook on one end, is dipped into the solution, and then heated in the colorless flame of the lamp.

Section 5.

SECOND GROUP.

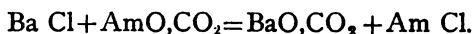
BARIUM, Ba. STRONTIUM, Sr. CALCIUM, Ca. MAGNESIUM, Mg.

Neutral Phosphates, and Carbonates, of this group are insoluble.

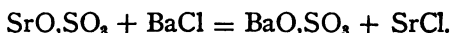
Section 6

BARIUM, Ba.

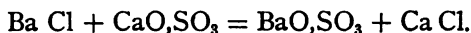
Proto-compounds of Barium, give with *Carbonate of Ammonia*, a white precipitate of CARBONATE OF BARYTA, easily decomposed by dilute acids.



Soluble proto-compounds of Barium, give with *Sulphate of Strontia*, a precipitate of SULPHATE OF BARYTA, insoluble in acids.



With *Sulphate of Lime*, soluble compounds of Barium give a white precipitate of SULPHATE OF BARYTA, which appears immediately.

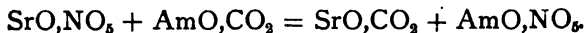


Compounds of Barium (except the Silicate) colour the flame *yellowish-green*.

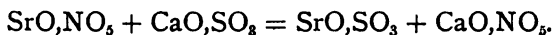
Section 7.

STRONTIUM, Sr.

Soluble proto-compounds of Strontium, give with *Carbonate of Ammonia*, a white precipitate of CARBONATE OF STRONTIA, easily decomposed by dilute acids.



Soluble proto-compounds of Strontium, give with *Sulphate of Lime*, white SULPHATE OF STRONTIA, insoluble in acids, and which does not make its appearance immediately.

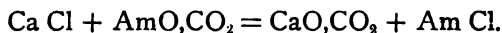


Compounds of Strontium, except Silicates, colour the flame *crimson*.

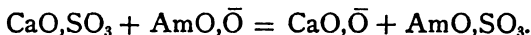
Section 8.

CALCIUM, Ca.

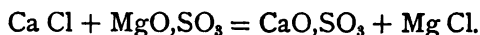
Soluble proto-compounds of Calcium, give with *Carbonate of Ammonia*, a white precipitate of CARBONATE OF LIME, easily decomposed by acids.



Ammonia and *Oxalate of Ammonia* cause, in solutions of proto-compounds of Calcium, a white precipitate of OXALATE OF LIME.



When *Sulphate of Magnesia* is added to a solution of a proto-compound of Calcium, with a few drops of alcohol, white SULPHATE OF LIME separates.



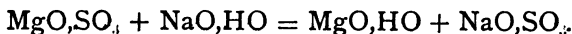
Salts of Calcium colour the flame *reddish yellow*.

Section 9.

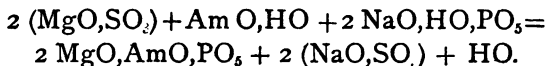
MAGNESIUM, Mg.

Soluble proto-compounds of Magnesium, give with *Carbonate of Ammonia* no precipitate, or one readily soluble in Chlorid of Ammonium.

Hydrate of Potassa or Soda cause, in a solution of a proto-compound of Magnesium, a white gelatinous precipitate of HYDRATED OXYD OF MAGNESIUM, soluble in acids.



When *Ammonia* and *Phosphate of Soda* are added to a solution of a proto-compound of Magnesium, a white crystalline precipitate of double PHOSPHATE OF AMMONIA and MAGNESIA separates. When the solution is a dilute one, the precipitate separates only after some time.



Compounds of Magnesium do not colour the flame.

Section 10.

SEPARATION OF MEMBERS OF THE SECOND GROUP.

To a small portion of the solution add Sulphate of Strontia, a white precipitate. separates. BARIUM, Sec. 6.

To the other portion add dilute SO_3HO while boiling, filter and wash the precipitate thoroughly.

A small portion of the precipitate upon the filter heated in the flame, colours it crimson from the presence of STRONTIUM, Sec. 7.

To the filtrate add Ammonia and Oxalate of Ammonia. Allow to stand twenty-four hours. A white precipitate. CALCIUM, Sec. 8.

Filter, and add Phosphate of Soda. A white precipitate. MAGNESIUM, Sec. 9.

Section 11.

THIRD GROUP.

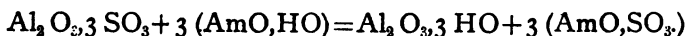
ALUMINIUM, Al. CHROMIUM, Cr.

Oxids, Carbonates, and Phosphates of this group are insoluble in neutral solutions. Sulphid of Ammonium precipitates them in the form of Oxids.

Section 12.

ALUMINIUM, Al.

Soluble sesqui-compounds of Aluminium, give with *Ammonia*, a white gelatinous precipitate of HYDRATED SESQUI-OXID OF ALUMINIUM, insoluble in an excess of the reagent.



With *Potassa or Soda*, soluble sesqui-compounds of Aluminium give the same precipitate as with *Ammonia*, but soluble in an excess of the precipitant. The Alumina is reprecipitated, however, upon the addition of *Chlorid of Ammonium* to the solution, and heating it.

Compounds of Aluminium, except Silicates, when moistened by a few drops of a solution of the *Proto-nitrate of Cobalt*, and heated upon charcoal by the blow-pipe, give a *bright blue slag*.

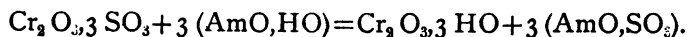
Section 13.

CHROMIUM, Cr. (*Sesqui-compounds*.)

Sesqui-compounds of Chromium are coloured green or violet.

Soluble sesqui-compounds of Chromium, give with *Ammonia*, a dirty green precipitate of HYDRATED SES-

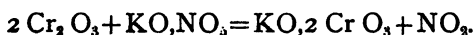
QUI-OXID OF CHROMIUM, slightly soluble in an excess, and imparts a purple colour to the solution.



With *Soda* or *Potassa*, the same precipitate is thrown down, but is easily dissolved in an excess, giving an emerald green solution.

Sesqui-compounds of Chromium, colour the borax bead *emerald green*.

When sesqui-compounds of Chromium are heated upon platina foil with *Nitrate of Potassa*, the Chromium is oxydized, and yellow BICHRIMATE OF POTASSA formed.



Section 14.

SEPARATION OF MEMBERS OF THE THIRD GROUP.

Add to the solution *Caustic Soda*, until all the precipitate is redissolved, and then boil. The SESQUI-OXID OF CHROMIUM will be precipitated, while the ALUMINA will remain in solution.

Section 15.

FOURTH GROUP.

ZINC, Zn. MANGANESE, Mn.

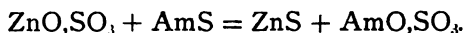
IRON, Fe. COBALT, Co. NICKEL, Ni.

Oxids, Carbonates, and Phosphates of this group, are insoluble in neutral solutions. *Sulphid of Ammonium* precipitates them from neutral or alkaline solution as sulphids, soluble in acids, but insoluble in alkalis.

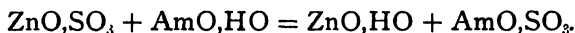
Section 16.

ZINC, Zn.

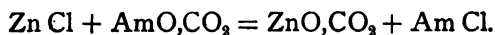
Soluble proto-compounds of Zinc, give with *Sulphid of Ammonium*, white SULPHID OF ZINC, easily decomposed by acids, but insoluble in Acetic Acid.



With *Ammonia*, *Soda*, or *Potassa*, soluble proto-compounds of Zinc, give a white precipitate of the HYDRATED PROTOXID OF ZINC, easily soluble in an excess of the precipitant.



With *Carbonate of Ammonia*, soluble proto-compounds of Zinc, give a white precipitate of the CARBONATE OF ZINC, soluble in an excess of the precipitant.

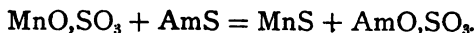


Section 17.

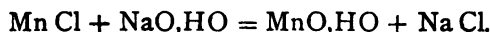
MANGANESE, Mn

Proto-compounds of Manganese, are of a light pink colour.

Soluble proto-compounds of Manganese, give with the *Sulphid of Ammonium*, a flesh-colored precipitate of the PROTO-SULPHID OF MANGANESE, decomposed by Acetic Acid.



With *Soda* or *Potassa*, soluble proto-compounds of Manganese, give a whitish precipitate of HYDRATED PROTOXID OF MANGANESE, which, upon standing, turns brown from the formation of the Sesquioxid.



Compounds of Manganese colour the borax bead *amethyst* colour.

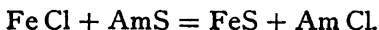
When fused with the *Nitrate of Potassa* and *Carbonate of Soda* upon platinum foil, a light green salt of the *Permanganate of Soda* is obtained.

Section 18.

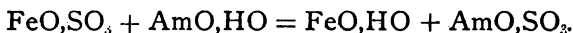
IRON, Fe. (*Proto-compounds.*)

Hydrous proto-salts of Iron are of a light green colour.

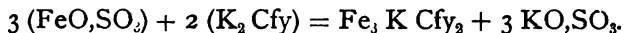
Soluble proto-compounds of Iron, give with the *Sulphid of Ammonium*, a black precipitate of the PROTO-SULPHID OF IRON, decomposed by dilute Hydrochloric Acid.



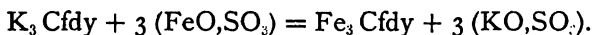
With *Potassa*, *Soda*, or *Ammonia*, soluble proto-compounds of Iron give a dirty green precipitate of the HYDRATED PROTOXID OF IRON, which turns brown from the formation of the sesquioxid.



With the *Ferrocyanid of Potassium*, soluble proto-compounds of Iron, give a bluish-white precipitate of FERROCYANID OF IRON and POTASSIUM.



With the *Ferricyanid of Potassium*, soluble proto-compounds of Iron, give a blue precipitate of FERRICYANID OF IRON.



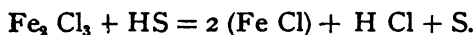
Proto-compounds of Iron impart to the borax bead, when heated upon charcoal, a *bottle green* colour.

Section 19.

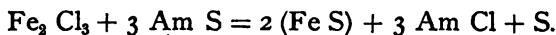
IRON, Fe. (*Sesqui-compounds.*)

Hydrous sesqui-compounds of Iron are yellowish red or brown.

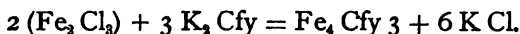
When *Hydrosulphuric Acid* is added to a solution of a sesqui-compound of Iron, the colour changes to a green, and SULPHUR is precipitated, the sesqui- being reduced to a proto-compound.



Soluble sesqui-compounds of Iron, give with *Sulphid of Ammonium*, a black precipitate of the PROTO-SULPHID OF IRON.

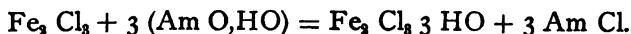


Soluble sesqui-compounds of Iron give, with the *Ferricyanid of Potassium*, a blue precipitate of PRUSSIAN BLUE.



Ferricyanid of Potassium, when added to a solution of a sesqui-compound of Iron, causes no precipitate, but deepens the colour of the solution.

Soluble sesqui-compounds of Iron, give with *Ammonia*, *Potassa*, or *Soda*, a red precipitate of the HYDRATED SESQUI-OXID OF IRON.



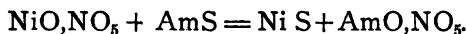
Sesqui-compounds of Iron colour the borax bead reddish-yellow.

Section 20.

NICKEL, Ni.

Hydrous salts of Nickel are of a green colour.

Soluble proto-compounds of Nickel, give with the *Sulphid of Ammonium*, a black precipitate of the PROTO-SULPHID OF NICKEL, not decomposed by dilute Hydrochloric Acid.



With *Soda* or *Potassa*, soluble proto-compounds of Nickel, give an apple-green precipitate of the HYDRATED OXID OF NICKEL.



With *Ammonia* the precipitate is dissolved in an excess, the solution being of a beautiful blue colour.

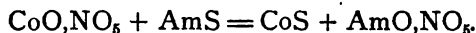
Compounds of Nickel colour the borax bead *violet* while hot, but *reddish brown* when cold.

Section 21.

COBALT, Co.

Hydrous proto-compounds of Cobalt are of a red colour.

With *Sulphid of Ammonium* soluble proto-compounds of Cobalt, give a black precipitate of the PROTO-SULPHID OF COBALT, insoluble in dilute Hydrochloric Acid.



With *Soda* or *Potassa*, soluble proto-compounds of Cobalt, give a blue precipitate of the HYDRATED PROTOXID OF COBALT, which turns green upon exposure to the air.



Ammonia produces the same precipitate, which is soluble however in an excess, giving a solution of a red colour which depends upon exposure to the air.

Compounds of Cobalt colour the borax bead *blue*.

Section 22.

SEPARATION OF MEMBERS OF THE FOURTH GROUP.

Add to the boiling solution of the members of this group an excess of *Sulphid of Ammonium*. Filter while hot, and wash with cold water, to which a few drops of Sulphid of Ammonium have been added.

To a large quantity of cold water add a very little dilute *Hydrochloric Acid*. Pour it over the precipitate upon the filter and wash thoroughly.

If the solution of Hydrochloric Acid has been dilute enough, the sulphids of IRON, ZINC, and MANGANESE will be decomposed and changed into chlorids, and washed through into the vessel beneath, while those of COBALT and NICKEL will remain upon the filter unchanged.

Decompose the insoluble SULPHIDS OF NICKEL and COBALT in strong *Nitro-hydrochloric Acid*. Evaporate until the excess of acid has disappeared, and add *Ammonia* until the precipitate caused has entirely dissolved. Set aside for a few days, when as the excess of Ammonia passes off the NICKEL (Section 20) will separate as a green powder, while the fluid will assume a darker red from the oxydation of the COBALT. Section 21.

To the solution of the chlorids add *Ammonia* to alkaline reaction, and then an excess of *Acetic Acid*. Heat the mixture until it loses its deep red color, and filter as rapidly as possible. The Iron will be precipitated as the BASIC ACETATE OF IRON. Section 19.

Wash the precipitate and acidulate the filtrate with a few drops of Acetic Acid. Now add *Sulphuretted Hydrogen* until the fluid smells distinctly of the gas. The ZINC will all be precipitated as the PROTO-SULPHID OF ZINC. Section 16.

To the filtrate from the Sulphid of Zinc, add an excess of *Ammonia*. The MANGANESE will be precipitated as the PROTO-SULPHID OF MANGANESE. Section 17.

Section 23.

FIFTH GROUP.

SILVER, Ag. MERCURY, Hg. LEAD, Pb. COPPER, Cu.
BISMUTH, Bi.

Oxids*, Carbonates, Phosphates, and Sulphids of this group are insoluble in neutral or alkaline solutions. The Sulphids are insoluble in dilute acids.

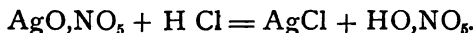
Section 24.

SILVER, Ag.

Soluble proto-compounds of Silver, give with *Hydro-sulphuric Acid*, a black precipitate of PROTO-SULPHID OF SILVER insoluble in Sulphid of Ammonium.



With *Hydrochloric Acid* soluble proto-compounds of Silver, give a white caseous precipitate of the PROTO-CHLORID OF SILVER, soluble in Ammonia, from which it is reprecipitated upon the addition of an acid.



Potassa, *Soda*, or *Ammonia*, cause in soluble proto-compounds of Silver, a brown precipitate of the HYDRATED PROTOXID OF SILVER, soluble in a slight excess of Ammonia.

* Protoxids of Silver, Mercury, and Lead, are slightly soluble in water.



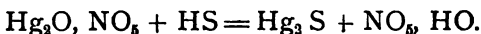
When any compound of Silver in a dry state, is mixed with three or four times its bulk of *Carbonate of Soda*, and heated by the blowpipe upon charcoal, the Silver separates in the form of small metallic globules.

Section 25.

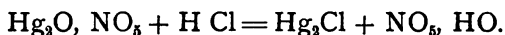
MERCURY, Hg. (*Sub-compounds.*)

All compounds of Mercury are volatilized, when heated upon platinum foil to a low red heat.

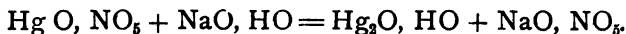
When *Hydrosulphuric Acid*, is added to a solution of a sub-compound of Mercury, the black SUB-SULPHID OF MERCURY is thrown down.



When *Hydrochloric Acid*, or a solution of any *Chlorid*, is added to a solution of a sub-compound of Mercury, white insoluble SUB-CHLORID OF MERCURY is thrown down. This turns black, upon the addition of Ammonia.



When *Soda* or *Potassa* is added to a solution of a sub-compound of Mercury, the black HYDRATED SUB-OXID OF MERCURY is thrown down.

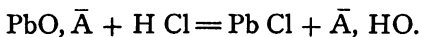


When a clean piece of *Copper* is boiled in a solution of a compound of Mercury, some Copper is dissolved, and the Mercury separates, covering over the surface of the Copper with a grey film. When this is carefully dried and heated in a dry test tube, the Mercury is volatilized, and condenses upon the cooler part of the tube in minute globules.

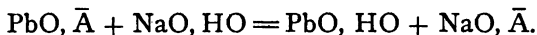
Section 26.

LEAD, Pb.

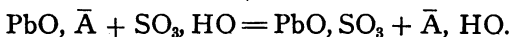
When *Hydrochloric Acid*, or any soluble chlorid, is added to a not too dilute solution of a proto-compound of Lead, a white precipitate of the PROTO-CHLORID OF LEAD is thrown down. This is soluble in an excess of boiling water, from which it crystallizes upon cooling.



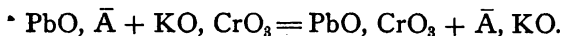
When *Potassa* or *Soda* is added to a solution of a proto-compound of Lead, the white HYDRATED PROTOXYD OF LEAD is precipitated, soluble in an excess of the precipitant. The precipitate from *Ammonia*, is not soluble in an excess.



When *Sulphuric Acid*, or any soluble sulphate, is added to a solution of a proto-compound of Lead, white SULPHATE OF LEAD is precipitated, insoluble in dilute Acids.



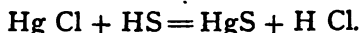
When a solution of *Chromate of Potassa* is added to a solution of a proto-compound of Lead, the yellow CHROMATE OF LEAD is precipitated. This is soluble in Soda or Potassa, but with difficulty in Nitric Acid.



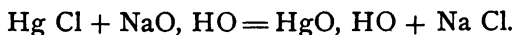
Section 27.

MERCURY, Hg. (*Proto-compounds.*)

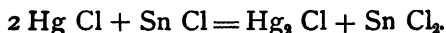
Soluble proto-compounds of Mercury, give with *Hydro-sulphuric Acid*, at first a white, then a yellow, brown, and finally a black precipitate of the PROTO-SULPHID OF MERCURY.



With *Potassa* or *Soda*, soluble proto-compounds give a yellowish precipitate of the HYDRATED PROTOXID OF MERCURY, soluble in Cyanid of Potassium.



Protochlorid of Tin, added to a soluble proto-compound of Mercury, reduces it, and we have a white precipitate of the SUB-CHLORID OF MERCURY.

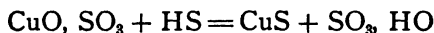


Section 28.

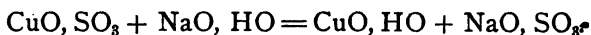
COPPER, Cu.

Hydrous compounds of Copper are of a green or greenish-blue colour.

Soluble proto-compounds of Copper, when treated with *Hydrosulphuric Acid*, are precipitated as black PROTO-SULPHID OF COPPER.

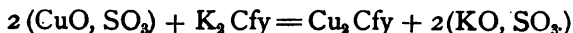


When *Soda* or *Potassa* is added to a soluble proto-compound of Copper, a light blue HYDRATED PROTOXID OF COPPER separates.



When *Ammonia* is added to a solution of a proto-compound of Copper the HYDRATED PROTOXID separates. It is soluble in an excess giving a BLUE solution.

Ferrocyanid of Potassium, gives with solutions of proto-compounds of Copper, a wine-red precipitate of FERRO-CYANID OF COPPER.

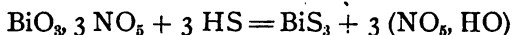


When *Metallic Iron or Zinc* is added to a solution of Copper, red METALLIC COPPER separates, adhering to the surface of the Iron or Zinc.

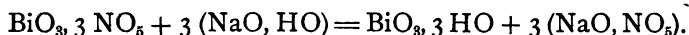
Section 29.

BISMUTH, Bi. (*Ter-compounds.*)

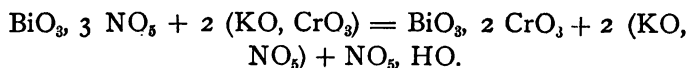
Soluble compounds of Bismuth, give with *Hydrosulphuric Acid*, black TERSULPHID OF BISMUTH, insoluble in Sulphid of Ammonium.



Potassa, Soda, or Ammonia, throws down from solution of Salts of Bismuth, white TEROXID OF BISMUTH, insoluble in an excess of the precipitant or in Cyanid of Potassium.



With *Chromate of Potassa*, Salts of Bismuth in solution give yellow basic CHROMATE OF BISMUTH, soluble in Nitric Acid, but insoluble in Soda.



Dilute *Sulphuric Acid* causes no precipitate in Solution of Bismuth. When *water* is added in large quantities to solutions of Salts of Bismuth, a dazzling white precipitate of a basic salt separates.

Section 30.

SEPARATION OF MEMBERS OF THE FIFTH GROUP.

To the solution add *Hydrochloric Acid*, when all the SILVER and SUB-CHLORID OF MERCURY will be precipitated as insoluble Chlorids [together with a portion of the Lead]. Heat to boiling. Filter and wash with boiling

water until a drop of the filtrate shows no reaction of Lead.

To the chlorids upon the filter add *Ammonia*. The Chlorid of Silver will pass through, being dissolved, while the Sub-chlorid of Mercury will turn black and remain undissolved.

Examine the filtrate for SILVER, Sec. 24.

Dissolve the black residue in strong *Nitric Acid* and examine the solution for MERCURY, Sec. 27.

To the filtrate from Chlorids of Mercury and Silver, add dilute *Sulphuric Acid* and warm, all the LEAD will be precipitated as the sulphate. Filter, Sec. 26.

To the filtrate from the Sulphate of Lead add *Ammonia* in excess. All the COPPER will be dissolved giving a blue solution. Filter and examine the filtrate for Copper, Sec. 28.

Wash the Oxids of Mercury and Bismuth upon the filter with cold water containing *Cyanid of Potassium* in solution. All the Mercury will be dissolved as Cyanid of Mercury.

In the Cyanid of Potassium solution the MERCURY may be detected by *Hydrosulphuric Acid*.

Dissolve the TER-OXYD OF BISMUTH remaining upon the filter in *Hydrochloric Acid*, and test to be sure that it is Bismuth, Sec. 29.

Section 31.

SIXTH GROUP.

ARSENIC, As. GOLD, Au. TIN, Sn. PLATINUM, Pt.
ANTIMONY, Sb.

All Carbonates, Phosphates, and Sulphids of this group

are insoluble in neutral solutions. The Sulphids are soluble in Alkaline Sulphids, but insoluble in Acids.

Section 32.

ARSENIC, As. (*Ter and Penta-compounds.*)

When a soluble Penta-compound is treated with *Hydro-sulphuric Acid*, it is reduced to a Ter-compound. When *Hydro-sulphuric Acid* is added to an acid solution of a Ter-compound of Arsenic, yellow TER-SULPHID OF ARSENIC is precipitated, soluble in an excess of Sulphid of Ammonium. Upon the addition of an acid, the PENTA SULPHID is precipitated. Both sulphids are soluble in *Carbonate of Ammonia*.



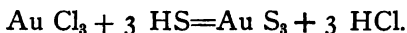
When a dry oxy-compound of Arsenic is heated in a dry test tube with anhydrous *Acetate of Soda*, KACKODYL, $\text{C}_4 \text{ H}_6 \text{ As}$, is given off. This smells like garlic.

When any dry compound of Arsenic is thrown upon red-hot charcoal, it is volatilized, and a garlic-like odour given off.

Section 33.

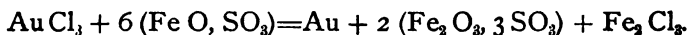
GOLD, Au. (*Ter-compounds.*)

Solutions of salts of gold are coloured yellow. Solutions of salts of gold, give with *Hydro-sulphuric acid*, a brownish-black TER-SULPHID OF GOLD, soluble in Sulphid of Ammonium, but insoluble in Carbonate of Ammonia.



When Proto-salts of Iron are added to a solution of Gold, the Gold separates in the metallic state, in the form of a

brown powder, insoluble in Hydrochloric or Nitric Acid, but soluble in aqua regia.

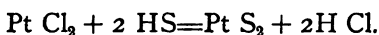


When we add to a solution of a salt of Gold, free from nitric acid, a mixture of a *proto* and a *bi-compound of Tin* or a few drops of *proto-chlorid of Tin* and then concentrated *Nitric Acid*, we have, in a very dilute solution, a purple colour, but in a more concentrated solution, a precipitate of *gold purple* (PURPLE OF CASSIUS).

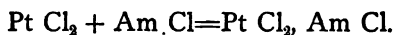
Section 34.

PLATINUM, Pt. (*Bi-compounds.*)

Salts of Platinum are coloured red or reddish-yellow. Bi-compounds of Platinum in solution give, with *Hydro-sulphuric acid*, black BI-SULPHID OF PLATINUM, which often is only precipitated upon warming, and which is soluble in Sulphid of Ammonium.



When *Chlorid of Ammonium* is added to a concentrated solution of a Platinum salt, a yellow crystalline precipitate of the double CHLORID OF AMMONIUM AND PLATINUM separates.

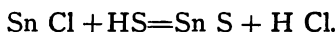


When a *Proto-salt of Iron* is added to a solution of a salt of Platinum, with *Soda* to alkaline reaction, and then heated to boiling, the *Binoxid of Platinum* is reduced to the metallic condition which, when an excess of Hydrochloric acid is added, remains undissolved in the form of black powder.

Section 35.

TIN, Sn. (*Proto-compounds.*)

When *Hydrosulphuric Acid* is added to a solution of a proto-compound of Tin, blackish-brown PROTOSULPHID OF TIN separates ; soluble in Sulphid of Ammonium, and only slightly so in Carbonate of Ammonia.

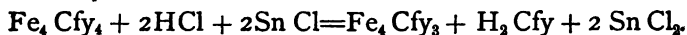


When the solution in Sulphid of Ammonium is acidulated with an acid, the yellow BISULPHID is precipitated.

When *Soda*, *Potassa*, or *Ammonia*, is added to a solution of a proto-compound of Tin, the white HYDRATED PROTOXID of TIN is thrown down ; soluble in an excess of the two first reagents, but nearly insoluble in the last.



When a few drops of a solution of *Ferricyanid of Potassium* are added to an acid solution of a proto-compound of Tin, and then some *Sesqui-chlorid of Iron*, PRUSSIAN BLUE separates immediately. The sesqui-chlorid of Iron is reduced to the proto-chlorid, the proto-chlorid of Tin being raised to a bi-chlorid.



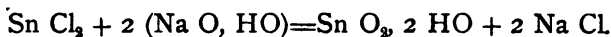
Section 36.

TIN, Sn. (*Bi-compounds.*)

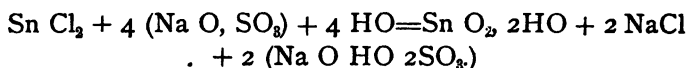
When *Hydrosulphuric Acid* is added to a solution of a bi-compound of Tin, at first a white flocculent precipitate is formed, which, upon the addition of more acid, changes to a yellow, and which consists of the BI-SULPHID of TIN, soluble in Sulphid of Ammonium.



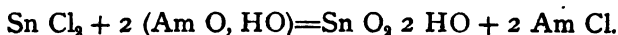
When *Potassa*, *Soda*, or *Ammonia* is added to an acid solution of a bi-compound of Tin, the HYDRATED BINOXID of TIN separates ; soluble in Soda or Potassa.



When *Sulphate of Soda* is added to a not too acid solution of a bi-compound of Tin, white HYDRATED BINOXID of TIN separates.



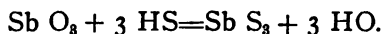
With soluble bi-compounds of Tin, *Ammonia* gives a white precipitate, insoluble in an excess of the reagent.



Section 37.

ANTIMONY, Sb. (*Ter and penta-compounds.*)

When acid, soluble compounds of Antimony are treated with *Hydrosulphuric acid*, orange-red TERSULPHID OF ANTIMONY, is precipitated. This is insoluble in acids and in the Carbonate of Ammonia, but soluble in the Sulphid of Ammonium, from which it is reprecipitated by an acid in the form of the PENTA-SULPHID OF ANTIMONY.



Ammonia, *Potassa*, or *Soda*, throws down from an acid solution of the Ter-compounds of Antimony, white TER-OXID of ANTIMONY, insoluble in Ammonia, but soluble in an excess of Potassa or Soda, and precipitated from the solution upon the addition of Chlorid of Ammonium. When Tartaric Acid is present there is no precipitate.



When a mixture of an oxy-compound of Antimony, Carbonate of Soda, and Cyanid of Potassium, is heated upon Charcoal, small brittle globules of METALLIC ANTIMONY are obtained.

Section 38.

SEPARATION OF THE MEMBERS OF THE SIXTH GROUP.

Add *Hydrosulphuric Acid* to the acid solution until the fluid smells distinctly of the gas. Warm, filter, and wash thoroughly. To the Sulphids upon the filter add *Carbonate of Ammonia*, to which a few drops of acid have been added, or which has been changed to the Bi-carbonate by passing Carbonic Acid through a solution of the Protocarbonate. Add until all the ARSENIC has been removed. Sec. 32.

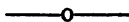
Dissolve the remaining sulphids upon the filter in *Nitro-Hydrochloric Acid*, and evaporate until all excess of acid has been driven off. Dilute with water and add a solution of the *Sulphate of Soda*. Upon warming and standing for a short time all the TIN will be precipitated as the Hydrated Bin-oxid. Sec. 36.

Filter, and to the filtrate add some crystals of the *Protosulphate of Iron*, and warm. All the GOLD will be precipitated in the form of a brown powder. Sec. 33.

Filter, and to the filtrate add an excess of *Soda*, and boil. Add Hydrochloric Acid to acid reaction, when all the Iron will be dissolved, while the PLATINUM will remain undissolved in the form of a black powder. Sec. 34.

Filter, and pass *Hydrosulphuric Acid* through the filtrate, when the ANTIMONY will all be precipitated together with some Sulphur. Sec. 37.

ACIDS.



Section 39.

The Acids or Salt Radicals are divided into groups like the metals, according to their reactions.

Section 40.

FIRST GROUP.

Acids which are precipitated from their neutral solution upon the addition of *Chlorid of Barium*.

CHROMIC ACID, CrO_3 , HO. SULPHUROUS ACID, SO_2 , HO. HYPOSULPHUROUS ACID, S_2O_2 , HO. SULPHURIC ACID, SO_3 , HO. HYDROFLUORIC ACID, HF. PHOSPHORIC ACID, PO_5 , 3 HO. BORACIC ACID, BoO_3 , HO. OXALIC ACID, C_2O_3 , HO, or $\overline{\text{O}}$, HO. CARBONIC ACID, CO_2 , HO, and SILICIC ACID, SiO_2 , HO.

This group is subdivided into :

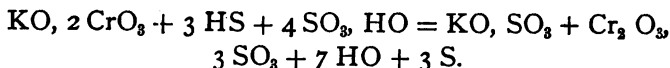
1st. Those acids that are decomposed in an acid solution upon the addition of *Hydrosulphuric Acid*, or of a strong acid, viz. CHROMIC ACID, CrO_3 , HO, SULPHUROUS ACID, SO_2 , HO, and HYPOSULPHUROUS ACID, S_2O_2 , HO.

Section 41.

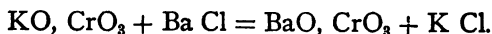
CHROMIC ACID, CrO_3 , HO.

All Chromates are red or yellow.

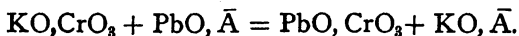
When *Hydrosulphuric Acid* is added to an acid solution of a Chromate, the Chromic acid is reduced, and SULPHUR separates. The solution at first turns brown, and then green from the formation of the SESQUIOXID OF CHROMIUM.



Chlorid of Barium causes, in a neutral solution of a chromate, a light yellow precipitate of CHROMATE OF BARYTA, insoluble in dilute Acetic Acid.



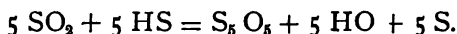
When *Acetate of Lead* is added to a neutral solution of a chromate, yellow CHROMATE OF LEAD separates, insoluble in Acetic Acid, but soluble in Hydrate of Soda.



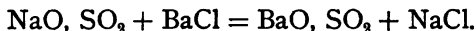
Section 42.

SULPHUROUS ACID, SO_2 , HO.

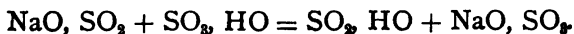
When *Hydrosulphuric Acid* is added to an acid solution of a sulphite, SULPHUR is precipitated, water and Penta-thionic Acid being formed.



Chlorid of Barium precipitates from neutral solution of the sulphites, white SULPHITE OF BARYTA, but not when the Sulphurous Acid is free.



When *Sulphuric Acid*, or any strong acid, is added to a Sulphite, SULPHUROUS ACID is set free, and may be recognised by the smell.



Section 43.

HYPOSULPHUROUS ACID, S_2O_3 , HO.

When *Hydrochloric Acid*, or any strong acid, is added to a solution of a Hyposulphite, and the Hyposulphurous Acid set free, it is decomposed into SULPHUR and SULPHUROUS ACID. The latter may be detected by its odour.



When *Hyposulphite of Soda* is added to moist *Chlorid of Silver*, the latter is all dissolved.

Section 44.

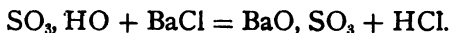
2d. Acids that are precipitated from acid solutions by *Chlorid of Barium*.

SULPHURIC ACID, SO_3 , HO. HYDROFLUORIC ACID, HF.

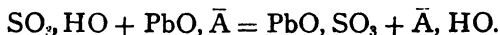
Section 45.

SULPHURIC ACID, SO_3 , HO.

When *Chlorid of Barium* is added to a solution containing Sulphuric Acid, either free or in combination with a base, white insoluble SULPHATE OF BARYTA separates.



Acetate of Lead, when added to a solution containing Sulphuric Acid, causes a precipitate of SULPHATE OF LEAD, insoluble in dilute acids.



When any oxy-compound of Sulphur in the dry state, is mixed with *Carbonate of Soda*, and heated upon charcoal with the blowpipe, it is reduced to a SULPHID. When

this is moistened with a dilute acid, Sulphuretted hydrogen is given off, which may be detected by the odour.

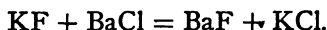
If an excess of the carbonate has been avoided, the fused mass has a brownish-yellow colour. A portion placed upon a piece of bright silver, and moistened with a drop of Hydrochloric Acid, colours the silver reddish-black from the formation of the sulphid.

The addition of *Lime Water*, or the *Sulphate of Lime*, to *Sulphuric Acid*, or to a *soluble Sulphate*, causes no precipitate.

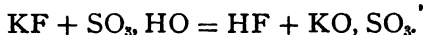
Section 46.

HYDROFLUORIC ACID, HF.

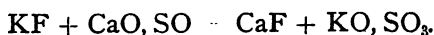
With *Chlorid of Barium*, Hydrofluoric Acid, or a soluble Fluorid, gives a precipitate of the FLUORID OF BARIUM, insoluble in acids.



When any Fluorid is mixed with a few drops of strong *Sulphuric Acid*, HYDROFLUORIC ACID is given off. This attacks glass that is brought in contact with it, and as it is evolved, passes off in dense white fumes.



When *Lime Water* or the *Sulphate of Lime* is added to a solution of a Fluorid, white gelatinous FLUORID OF CALCIUM is precipitated.



Section 47.

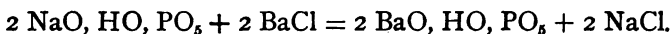
3d. Acids which are precipitated from neutral solutions by *Chlorid of Barium* :—PHOSPHORIC ACID, PO_5 .

3 HO ; BORACIC ACID, BoO_3 , HO ; CARBONIC ACID, CO_2 ; HO ; SILICIC ACID, SiO_2 , HO ; OXALIC ACID, $\bar{\text{O}}$, HO.

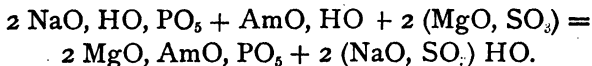
Section 48.

PHOSPHORIC ACID, PO_5 , 3 HO.

When *Chlorid of Barium* is added to a neutral, or an alkaline solution of a Phosphate, white PHOSPHATE OF BARYTA separates. It is soluble in Acetic Acid.



When *Ammonia* and *Sulphate of Magnesia* are added to a solution of a Phosphate, white crystalline PHOSPHATE OF MAGNESIA AND AMMONIA separates.

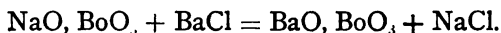


When a solution of a Phosphate is made slightly acid by a few drops of Nitric or Hydrochloric Acid, then a very small portion of the Sesqui-chlorid of Iron added, and an excess of the Acetate of Soda, a yellowish-white precipitate of the Phosphate of the Sesquioxid of Iron separates.

Section 49.

BORACIC ACID. BoO_3 , HO.

Chlorid of Barium, produces in concentrated neutral or alkaline solution of Borates, a white precipitate of BORATE OF BARYTA, soluble in dilute Acetic Acid and in ammoniacal salts.



If a Borate is mixed with Alcohol and Strong Sulphuric Acid added, when the Alcohol is ignited, the flame

will be coloured greenish-yellow by the Boracic Acid set free.

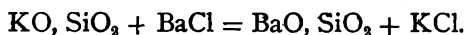
When a solution of a Borate is made slightly acid by the addition of Hydrochloric Acid, and a slip of *Turmeric paper* is dipped half its length into it, and then dried, the moistened half will show a peculiar red tint.

Section 50.

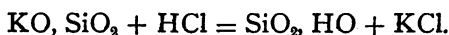
SILICIC ACID, SiO_2 , HO.

Only the silicates of the alkalies are soluble in water.

With *Chlorid of Barium*, solutions of the silicates give a gelatinous precipitate of the SILICATE OF BARYTA, soluble in Acetic Acid.



When *Hydrochloric Acid* is added to a not too dilute solution of a silicate, gelatinous Silicic Acid separates, which is insoluble in an excess of the acid. Sometimes when the solution is very dilute, Silicic Acid does not separate, but if the mixture is evaporated to dryness, upon the addition of water it remains undissolved as a white gritty powder.



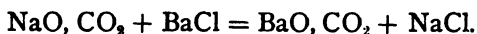
When an insoluble silicate is fused with four or five parts of *Carbonate of Soda* and *Potassa*, until all effervescence has ceased, upon treating the mass with water the Silicic Acid will go into solution in the form of an alkaline silicate. The insoluble oxids will remain and may be examined after solution in Hydrochloric Acid.

Section 51.

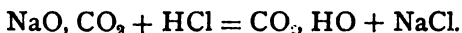
CARBONIC ACID, CO_2 , HO.

When *Chlorid of Barium* is added to a neutral or alka-

line solution of a Carbonate, white CARBONATE OF BARYTA is precipitated, which is easily decomposed by Acetic Acid with effervescence.



When any free acid is added to a solution of a Carbonate, effervescence occurs, the CARBONIC ACID being set free.



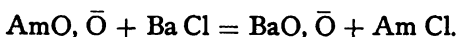
A lighted match plunged into the escaping gas is instantly extinguished. A drop of lime water on the end of a glass rod is rendered turbid by it, from the formation of the CARBONATE OF LIME.

Litmus paper moistened and placed in the gas, turns red, but upon drying resumes its blue colour.

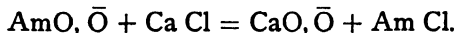
Section 52.

OXALIC ACID, C_2O_3 , HO, or $\bar{\text{O}}$, HO.

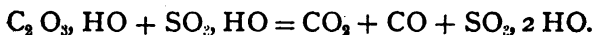
When *Chlorid of Barium* is added to a solution of an Oxalate, white OXALATE OF BARYTA is precipitated, insoluble in dilute Acetic Acid.



When any soluble compound of *Calcium* is added to a neutral or alkaline solution of an Oxalate, white OXALATE OF LIME is precipitated. This is insoluble in Acetic Acid.



When dry Oxalic Acid, or an Oxalate in a dry state, is heated with an excess of strong *Sulphuric Acid*, the Oxalic Acid is decomposed, CARBONIC ACID and CARBONIC OXID are given off. The latter may be ignited at the mouth of the test-tube, and burns with a blue flame.



Section 53.

SECOND GROUP OF ACIDS.

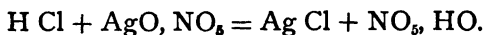
Acids which are not precipitated by *Chlorid of Barium*, but by *Nitrate of Silver* in acid solution.

HYDROCHLORIC, H Cl ; HYDROBROMIC, H Br ; HYDRIDIC, HI ; HYDROCYANIC, H Cy ; HYDRO-FERROCYANIC, H_2Cfy ; HYDRO-FERRICYANIC, H_3Cfdy ; HYDRO-SULPHURIC ACID, HS .

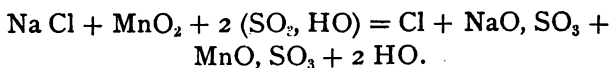
Section 54.

HYDROCHLORIC ACID, H Cl .

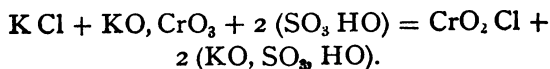
When *Nitrate of Silver* is added to a solution of a Chlorid or Hydrochloric Acid, white caseous CHLORID OF SILVER is precipitated, insoluble in Nitric Acid, but soluble in Ammonia.



When the *Binoxid of Manganese* is added to Hydrochloric Acid, or to a Chlorid with a few drops of strong Sulphuric Acid, CHLORINE is set free, and may be known by its odour and yellowish-green colour.



When a mixture of a dry Chromate and Chlorid, is heated with strong *Sulphuric Acid*, a deep brownish-red gas of CHLOROCHROMIC ACID is given off.



2*

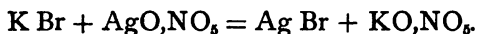
When this is allowed to pass into a solution of *Ammonia*, it is decomposed and yellow CHROMATE OF AMMONIA formed.



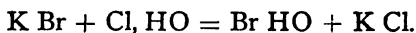
Section 55.

HYDROBROMIC ACID, HBr.

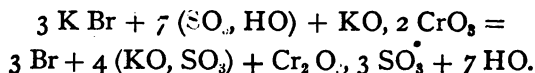
With *Nitrate of Silver*, Hydrobromic Acid, or any solution of a Bromid, gives a yellowish-white precipitate of the BROMID OF SILVER, insoluble in Nitric Acid, and with some difficulty soluble in Ammonia.



When *Chlorine* water is added to a solution of a Bromid or to Hydrobromic Acid in not too large a quantity, the fluid turns yellowish-red from liberated BROMINE. When too much Chlorine is added the colour is entirely discharged. A few drops of *Chloroform*, or the *Bisulphid of Carbon* added to the fluid, and the whole shaken well together, is coloured red from the Bromine dissolved by it.



If *Sulphuric Acid* and the *Bichromate of Potassa* are heated with a dry Bromid, a brownish-red gas is given off. This is BROMINE, and when passed into a solution of Ammonia does not colour it.

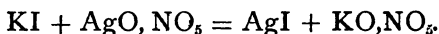


Section 56.

HYDRIODIC ACID, HI.

When *Nitrate of Silver* is added to a solution of an

Iodid, or Hydriodic Acid, yellowish-white IODID OF SILVER separates, sparingly soluble in Ammonia.



When *Chlorine* water, or a few drops of strong *Nitric Acid*, are added to a solution of an Iodid, or to Hydriodic Acid, IODINE is set free. This is indicated by the purple vapours that are given off. When a few drops of *Chloroform*, or *Bisulphid of Carbon*, are agitated with this, they assume a violet colour. Starch solution is coloured a beautiful blue.

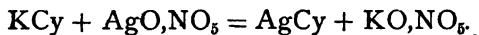


When a mixture of an *Iodid*, *Sulphuric Acid* and *Bichromate of Potassa* is heated, Iodine is given off, and may be recognised by its violet-coloured vapours.

Section 57.

HYDROCYANIC ACID, $\text{C}_2 \text{NH}$ or HCy .

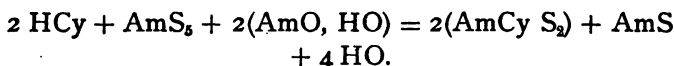
When *Nitrate of Silver* is added to a solution of a Cyanid, or to Hydrocyanic Acid, white CYANID OF SILVER is precipitated. This is soluble in Cyanid of Potassium, and with some difficulty in Ammonia, but insoluble in Nitric Acid. Heated upon Charcoal it is decomposed, and metallic silver remains.



When a mixture of the *Sulphate of the Protoxide* and the *Sesquichlorid of Iron* is added to an alkaline cyanid, and then an excess of *Hydrochloric Acid*, PRUSSIAN BLUE is precipitated.

When a solution of a Cyanid is mixed with a slight excess of yellow *Sulphid of Ammonium* until the solution appears yellowish, and then *Ammonia* added, and the mixture

warmed until it becomes colourless, and all excess of Sulphid of Ammonium is driven off, SULPHOCYANID OF AMMONIUM is formed. This when acidulated with *Hydrochloric Acid*, gives upon the addition of *Sesquichlorid of Iron*, a deep red colour. (When the Hydrochloric Acid is added there should be no evolution of Sulphuretted Hydrogen.)

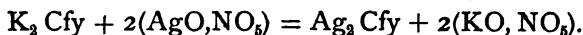


Cyanid of Mercury does not react as other Cyanids. The Mercury must first be precipitated by Hydrosulphuric Acid and the Hydrocyanic Acid then tested.

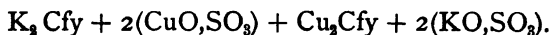
Section 58.

HYDROFERROCYANIC ACID, $\text{H}_2 \text{Cy}_2$, Fe Cy or $\text{H}_2 \text{Cfy}$.

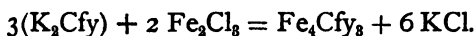
With *Nitrate of Silver*, solutions of Ferrocyanids, give a white precipitate of the FERROCYANID OF SILVER, insoluble in Nitric Acid or Ammonia.



With *Sulphate of Protoxid of Copper*, solutions of Ferrocyanids give wine-red FERROCYANID OF COPPER.



With the *Sesquichlorid of Iron*, solutions of the Ferrocyanids give a blue precipitate of the FERROCYANID OF IRON.

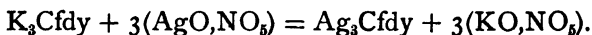


Section 59.

HYDROFERRICYANIC ACID, $\text{H}_3 \text{Cy}_3$, $\text{Fe}_2 \text{Cy}_3$ or $\text{H}_3 \text{Cfdy}$.

With *Nitrate of Silver* solutions of Ferricyanids give an

orange-coloured precipitate of FERRICYANID OF SILVER ; insoluble in Nitric Acid but soluble in Ammonia.



With the *Sesquichlorid of Iron*, solutions of the Ferricyanids give no precipitate, but only a deep red colour.

With *Protosalts of Iron* Ferricyanids give a blue precipitate of the FERRICYANID OF IRON.

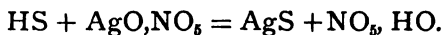


Section 60.

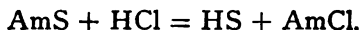
HYDROSULPHURIC ACID, HS.

Free Hydrosulphuric Acid may be recognised by its odour, which resembles that of putrid eggs.

When *Nitrate of Silver* is added to Hydrosulphuric Acid, or a solution of a Sulphid, black PROTOSULPHID OF SILVER is precipitated.



When *Hydrochloric Acid* is added to a solution of a Sulphid, HYDROSULPHURIC ACID is given off. When this is in such small quantities as to elude the sense of smell, a piece of unsized paper, moistened with a solution of the *Acetate of Lead* placed above the liquid, will be coloured yellow, yellowish-brown, or black, according to the amount of the gas given off.



Any soluble sulphid in the dry state, upon being placed upon a bright piece of Silver, and moistened with water, stains the metal black from the formation of the SULPHID OF SILVER.

THIRD GROUP OF ACIDS.

Section 61.

Acids which do not form insoluble precipitates with salts of *Barium* or of *Silver*.

NITRIC ACID, CHLORIC ACID, ACETIC ACID.

Section 62.

NITRIC ACID, NO_3 , HO.

All Nitrates are soluble in water.

When a Nitrate in the dry state is thrown upon *Ignited Charcoal* DEFLAGRATION ensues.

When a nitrate is mixed with an equal volume of strong *Sulphuric Acid*, and the mixture allowed to cool, upon the addition of a solution of the *Sulphate of the Protoxyd of Iron*, it being added carefully so that the two shall not mix, the line where the two liquids join will show a purple or brownish tint from the oxidation of the Iron. If the solutions are now mixed, a clear brownish-purple fluid is obtained.

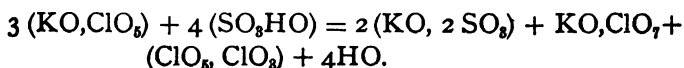
Section 63.

CHLORIC ACID, ClO_3 , HO.

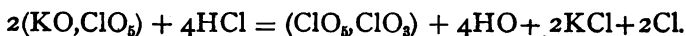
All Chlorates are soluble in water.

When any Chlorate in the dry state is thrown upon ignited *Charcoal* DEFLAGRATION ensues.

When strong Sulphuric Acid is added to a solution of a Chlorate, the Chlorate is decomposed, CHLOROCHLORIC ACID being set free, which colours the solution intensely yellow and gives off the odour of Chlorine.



When *Hydrochloric Acid* is added to a solution of a Chlorate, WATER, CHLORINE, and CHLOROCHLORIC ACID are given off.



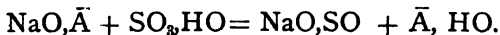
Section 64.

ACETIC ACID, $\text{C}_4\text{H}_8\text{O}_3$, HO or $\bar{\text{A}}$, HO.

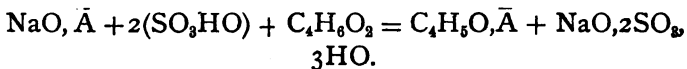
All Acetates are decomposed at a low red heat.

When a solution of the *Sesquichlorid of Iron* is added to a solution of an Acetate, and then *Ammonia* until the solution is nearly neutralized, the fluid turns to a dark red colour from the formation of the ACETATE OF THE SESQUI-OXID OF IRON. Upon boiling, the fluid becomes colourless, the Iron being precipitated as the basic Acetate.

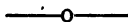
When an Acetate is heated with an excess of strong *Sulphuric Acid*, ACETIC ACID is given off.



When an Acetate is heated with an equal volume of strong *Sulphuric Acid*, and *Alcohol*, ACETATE OF THE OXID OF ETHYL is formed, which may be recognised by the agreeable odour given off.



PRELIMINARY EXAMINATION.



Section 65.

A careful examination of the physical properties, as colour, shape, etc., of the substance to be tested, may often lead to some modification of the regular course of analysis, and no substance should be analysed without an examination of this character.

(a.) THE SUBSTANCE TO BE EXAMINED IS A SOLID.

It should be finely pulverized* and a small portion tested by heating upon charcoal or upon a piece of platinum foil before the blowpipe flame, care being taken to use the least amount possible with satisfactory results.

IS EASILY VOLATILIZED WHEN HEATED UPON CHARCOAL.

Compounds of *Ammonium*. Some of *Sulphur*, detected by the odour. All compounds of *Arsenic*, recognised by the odour like that of garlic.

FUSES WITHOUT VOLATILIZING, AND WITHOUT CHANGE OF COLOUR.

The greater part of the salts of the *Alkalies*. Some

* If in large pieces, and quite hard, wrap a portion of it in a piece of strong paper and strike it a heavy blow with a hammer, then pulverize it more finely in a small porcelain or agate mortar.

of the *Alkaline earths*, some *Silicates*, and some *Fluorids*.

INTUMESCES. *Alum* and some hydrous salts.

FUSES, AND COVERS THE CHARCOAL WITH AN INCRUSTATION OF AN OXID.

Antimony, Lead, Bismuth, Tin, Arsenic, and Zinc.

FUSES WITH DIFFICULTY, GIVING A METALLIC BEAD.

Silver, Gold, and Copper.

DEFLAGRATES. All *Nitrates* and *Chlorates*.

IS INFUSIBLE AND WITHOUT CHANGE OF COLOUR.

Baryta, Strontia, Lime, Magnesia, Silicic Acid, and many *Silicates* with *Sesquioxid of Chromium, Aluminum*, and their salts.

ASSUMES A DARKER COLOUR WHEN HEATED.

Protoxide of Tin and *Antimonic Acid* turn *yellow*.

Protoxid of Lead, Teroxyde of Bismuth, and *Chromates* turn *brown*.

(b.) A small portion is intimately mixed with dry *Carbonate of Soda*, the mass slightly moistened and then heated upon Charcoal, as above, until the Soda melts.

THE MASS TURNS YELLOWISH-BROWN, and when moistened with dilute acid gives off the smell of *Hydrosulphuric Acid*, or a piece of the mass detached from the Charcoal, and laid upon a bright piece of Silver with a drop of water, colours it reddish-black: the presence of some *Sulpho* compound is indicated.

SHINING DUCTILE GLOBULES APPEAR.

Tin, Copper, Gold, or Silver.

GREY INFUSIBLE POWDER REMAINS.

Nickel, Cobalt, or Iron.

METALLIC GRAINS WITH AN INCRUSTATION.

BRITTLE and WHITE, *Antimony*.BRITTLE and BROWNISH-YELLOW, *Bismuth*.MALLEABLE YELLOW, *Lead*.

INCRUSTATION WITHOUT METALLIC GRAINS.

YELLOW when hot and WHITE when cold, *Zinc*.

- (c.) Moisten the loop of the Platinum wire with a drop of Hydrochloric Acid, dip it into the powder, and expose it to the outer flame of the blowpipe. It colours the flame :

YELLOW, *Sodium*, or a compound of the alkalies containing this element.VIOLET, *Potassium*.CRIMSON, *Strontium*.ORANGE, *Lime*.GREENISH-YELLOW, *Barium*.GREEN, *Copper* or *Boracic Acid*.BLUE, *Arsenic*, *Antimony*, *Lead*, *Chlorid* or *Bromid of Copper*.

- (d.) A small portion of the substance should now be heated in a glass tube closed at one end.

WATER IS GIVEN OFF, condensing upon the cool part of the tube. Some hydrous salts, or water of crystallization, etc.

DECREPITATES. Due to the water retained mechanically between the plates of the crystals, *Chlorid of Sodium*, *Fluorid of Calcium*, etc.

GAS IS GIVEN OFF. Without odour and extinguishing fire at the end of a match. *Carbonic Acid*.

ODOUR OF SULPHUROUS ACID. A *Metallic Sulphid*. (Usually when Sulphur is present in this form reddish-

yellow drops condense upon the cooler part of the tube.)

ODOUR LIKE GARLIC indicates the presence of *Arsenic*. Sometimes this condenses upon the tube, giving a brilliant metallic coating or mirror.

A WHITE COATING OR PRECIPITATION on the cooler part of the tube, if crystalline, indicates the presence of *Arsenious Acid*; if quite fusible, *Teroxide of Antimony*. Driven easily from one part of the tube to the other, some salt of *Ammonium*.

METALLIC COATING separating into minute globules. *Mercury*.

URNS BLACK. Some organic compound decomposed upon heating.

(e.) Fuse a small portion of the powder with "Phosphor Salt" (Phosphate of Soda, Ammonia and Water) in the outer flame of the blowpipe.

IT DOES NOT DISSOLVE BUT FLOATS IN THE HOT BEAD. *Silicic Acid* or a *Silicate*.

DISSOLVES, GIVING A COLOURLESS BEAD WHEN COLD, which is sometimes milky, *Alumina*, *Baryta*, *Strontia*, *Lime*, *Magnesia*. Remaining CLEAR WHEN COLD, *Oxid of Tin*. When in considerable quantities YELLOW WHEN HOT, but COLOURLESS WHEN COLD, *Zinc*, *Lead*, *Antimony*, OPAL *Bismuth*.

A YELLOWISH bead, which, when saturated, is of an opal colour, and viewed by the light of a candle, reddish, *Silver*.

AT FIRST YELLOWISH-RED, THEN GREEN, AND AT LAST COLOURLESS, or when a large quantity is present, at first dark red, and as it cools, reddish-brown, dirty green, and then brownish-red, *Iron*.

AT FIRST REDDISH, THEN YELLOW, or when a large quantity is present, at first brownish-red, and then reddish-yellow, *Nickel*.

VIOLET OR AMETHYST COLOURED. When the tint is very delicate, a crystal of Nitrate of Potassa, added to the bead while still hot, causes the colour to darken materially, *Manganese*.

BLUE. *Cobalt*. When hot, green, but when in large quantity, greenish-blue, *Copper*.

YELLOWISH-GREEN. When hot, reddish, but when cold, green, and when a crystal of Nitrate of Potassa is added, and the bead heated, turning yellow, and upon addition of a small piece of charcoal, green again, *Chromium*.

(f.) Take a portion of the finely divided substance, place it in a test tube, pour a few drops of strong Sulphuric Acid upon it, and heat gently.

COLOURLESS GAS GIVEN OFF, that burns with a blue flame, Carbonic Oxid from decomposition of *Oxalic Acid*.

SMELLS OF SULPHUROUS ACID, a *Sulphite* or a *Hyposulphite*.

GIVES OFF SMELL OF SULPHURETTED HYDROGEN, a *metallic Sulphid*.

A WHITE CURDY PRECIPITATE.

When a drop of Nitrate of Silver on a glass rod is held over it, a *metallic Chlorid*.

A PIECE OF IGNITED CHARCOAL burns brighter in the gas, and the substance turns brown, a *Chromate* or *Peroxid*.

A GAS THAT HAS NO ODOUR, but that extinguishes an ignited piece of charcoal, *Carbonic Acid*.

ODOUR OF BITTER ALMONDS indicates a *cyanid*. When the residue is bluish-green, a *ferro* or *ferri-cyanid*.

VIOLET VAPOURS sometimes condensing on the cooler part of the tube in small steel-coloured plates, an *Iodid*.

REDDISH BROWN VAPOUR, *Bromine*.

REDDISH FUMES, *Nitrous* or *Nitric Acid*.

A YELLOWISH GAS, smelling of chlorine, a *Hypochlorite* or a *Chlorate*.

WHITE FUMES that attack the glass, a *Fluorid*.

URNS BLACK from separation of Carbon, an *Organic Compound*.

NO GAS IS GIVEN OFF.—The substance may be an *Oxid*, *Phosphate*, *Silicate*, *Sulphate* or *Borate*.

Section 66.

THE SUBSTANCE TO BE EXAMINED IS A FLUID.

(a.) Evaporate a small portion to dryness upon platinum foil, to see whether there is anything in solution.

NO RESIDUE at a low red heat remains. The solution may contain *Ammonia*, *Carbonate of Ammonia*, or *Acetic Acid*.

A RESIDUE WHICH VOLATILIZES at a low red heat. A salt of *Ammonia* or *Mercury*, or *Sulphuric*, *Phosphoric*, *Nitric*, *Hydrochloric* or *Oxalic Acids*.

THE RESIDUE FUSES. A *salt of an alkali*.

REMAINS UNCHANGED. A salt of an *alkaline earth* or *Aluminum*.

BECOMES DARKER. Salt of a metal.

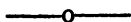
(b.) Test a portion of the fluid with Litmus paper.

THE SOLUTION IS NEUTRAL. Salt of an *alkali* or an *alkaline earth*. Absence of members of the 3d, 4th, 5th or 6th groups of Metals.

REACTS ALKALINE. Hydrate of an *alkali*, *Alkaline Earth*, *Oxid of Silver* or *Mercury*. If the fluid is yellow, it may consist of a Sulphid of the 6th group of Metals, in solution in an alkaline sulphid. The *Sesqui-oxid of Aluminium*, or *Chromium*, or *Prot-oxid of Zinc*, may be present dissolved in an alkali.

REACTS ACID. A free Acid, or it may be an acid salt of any of the Metals. To a drop of the solution, add a few drops of Carbonate of Soda. No precipitate, absence of all Metals of 2d, 3d, 4th, 5th or 6th groups.

SOLUTION OF BODIES.



Section 67.

Solution of Bodies.

If the substance is a fluid, pass on to the process of actual analysis, as in Sec. 68.

If a solid, take a small portion, finely divided, put it into a test tube with water, and heat.

If it is all dissolved. Pass on to Section 68.

If a portion or all remains unaffected. Decant a few drops of the clear liquid and evaporate to dryness. If there is a residue, filter, and set the filtrate aside for further examination, as under Section 68.

There is no residue upon the platinum foil. Pass on to (c) for it is not soluble in water.

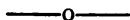
(c.) To the portion that is not dissolved, add Hydrochloric Acid. It dissolves completely. Pass on to Section 68.

A portion only is dissolved. Add now a few drops of strong Nitric Acid. Heat until all smell of Chlorine has ceased. Dilute with water and filter from the insoluble residue, if there is any, and treat the filtrate as in Section 68.

(d.) The insoluble residue may consist of Silicic Acid or a Silicate, Sulphates of Baryta, Strontia or Lead, Alumina, Sesquioxid of Chromium, Anhydrous Sesquioxid of Iron, Fluorid of Calcium or Cryolite, Chlorid, Bromid or Iodid of Silver, most of which have been detected in the preliminary examination.

Wash the insoluble residue free from all Acid, dry and mix with two parts Carbonate of Soda, two parts powdered Charcoal, and ten parts Nitrate of Potassa. Place the mixture in an iron spoon and heat. The mass will deflagrate, and upon cooling, a fused black residue will be found. Place the spoon in a small beaker, and cover with water. The mixture will slowly disintegrate, the carbon sink to the bottom, while the alkalies will go into solution. Filter. All the Fluorine, Chlorine, Bromine, Iodine, Sulphuric Acid, Alumina, and Chromium will pass through the filter, being in combination with, or in solution in the alkali, and may be tested for in the filtrate, as well as some Silicic Acid. Dissolve the residue after thorough washing in Hydrochloric Acid, and treat according to Sec. 68.

ACTUAL ANALYSIS,



ACTUAL ANALYSIS.

Section 68.

SIMPLE COMPOUNDS, ONE ACID AND ONE METAL.

DETECTION OF METALS.

To a portion of the fluid, if not made previously acid by it, add *Hydrochloric Acid*.

NO PRECIPITATE. Pass on to (*A*), for there is neither Silver, nor Suboxid of Mercury present, and if Lead, only in small quantities.

A WHITE PRECIPITATE. Soluble in boiling water, from which it is precipitated by dilute *Sulphuric Acid*, **LEAD.** *Soluble in Ammonia*, from which it is re-precipitated on addition of Hydrochloric Acid, **SILVER.**

Turns black upon addition of *Ammonia*, **SUBOXID OF MERCURY.** Sometimes **SULPHUR** separates from the decomposition of a Sulphite, or Hyposulphite, or there is an evolution of Sulphuretted Hydrogen. Also a separation of a gelatinous precipitate of **SILICA** insoluble in all menstrua.

(*A*.) To the solution in which Hydrochloric Acid has failed to produce a precipitate, add *Hydrosulphuric Acid* until the fluid smells strongly of it, and warm

NO PRECIPITATE. Absence of members of 5th and 6th groups. Pass on to (*B*).

WHITE PRECIPITATE OF SULPHUR. Indicates presence of a **CHROMATE** or a **SESQUISALT OF IRON**. If Iron is present, the solution takes a light green colour. If Chromium, the solution darkens.

AN ORANGE-COLOURED PRECIPITATE, ANTIMONY.

A YELLOW PRECIPITATE, ARSENIC or BINOXID OF TIN.
Dissolve in Nitrohydro-chloric Acid, and to the solution add an excess of Ammonia. A white precipitate indicates the presence of **TIN**. No precipitate, that it is **ARSENIC**.

A PRECIPITATE at first WHITE, then YELLOW, BROWN, AND FINALLY BLACK, MERCURY.

BROWN, BLACKISH-BROWN or black. The precipitate may be of **LEAD, COPPER, BISMUTH, PROTO-SULPHID OF TIN, GOLD, or PLATINUM**. Pour upon the precipitate upon the filter, *Sulphid of Ammonium*. It does not dissolve. This indicates that there is no **TIN, GOLD, or PLATINUM** present.

Dissolve the residue that is not dissolved by Sulphid of Ammonium in Nitric Acid. Evaporate nearly to dryness, and dilute largely. A white precipitate indicates **BISMUTH**. A few drops of dilute Sulphuric Acid cause a white insoluble precipitate, **LEAD**. The addition of Ammonia causes a blue precipitate soluble in excess, giving a deep blue fluid, **COPPER**.

THE PRECIPITATE WITH SULPHURETTED HYDROGEN

DISSOLVES IN THE SULPHID OF AMMONIUM. Add a few drops of dilute Hydrochloric Acid. The precipitate is *yellow*, TIN. It is *black*, then dissolve in Nitro-Hydrochloric Acid, and evaporate nearly to dryness. Dilute with a little water and add a few drops of Proto-chlorid of Tin. A *deep red colour*, PLATINUM. A few drops of strong Nitric Acid cause a *deep purple colour*, GOLD.

(B.) To the solution in which the Hydrochloric Acid or the Hydrosulphuric Acid has produced no precipitate, add a few drops of strong Nitric Acid and heat until all smell of Sulphuretted Hydrogen has passed off. Now add *Chlorid of Ammonium* and *Ammonia* to slight Alkaline reaction.

NO PRECIPITATE. Pass on to (C) for IRON, ALUMINUM, CHROMIUM, ZINC, COBALT, and NICKEL are not present.

A WHITE PRECIPITATE insoluble in an excess, ALUMINUM.

A WHITE PRECIPITATE soluble in an excess, but precipitated upon addition of Hydrosulphuric Acid, ZINC.

A DIRTY GREEN PRECIPITATE, without change upon addition of Sulphid of Ammonium, CHROMIUM.

A RED PRECIPITATE, SESQUI-COMPOUND OF IRON.

AN APPLE GREEN precipitate, soluble in an excess, NICKEL.

A BLUE PRECIPITATE, dissolving in excess, and giving a reddish-brown solution, COBALT.

(C.) To the solution in which Ammonia in the presence of Chlorid of Ammonium has caused no precipitate, add a few drops of the *Sulphid of Ammonium*.

NO PRECIPITATE. Pass on to (D), for no MANGANESE is present.

A FLESH-COLOURED precipitate, MANGANESE.

(D.) To the solution in which neither of the above reagents has caused a precipitate, add a few drops of *Carbonate of Ammonia* and warm.

NO PRECIPITATE. Pass on to (E), for there is no CALCIUM, STRONTIUM or BARIUM present.

A WHITE PRECIPITATE. CALCIUM, STRONTIUM or BARIUM.

Take a fresh portion of the solution and add to it a few drops of *Sulphate of Lime*. A WHITE PRECIPITATE that makes its appearance immediately, BARIUM. Only after some time, STRONTIUM. NO PRECIPITATE, CALCIUM.

(E.) To the fluid in which the Carbonate of Ammonia has failed to produce a precipitate, add some *Phosphate of Soda*.

NO PRECIPITATE. Pass on to (F), for there is no MAGNESIUM present.

A WHITE PRECIPITATE, MAGNESIUM.

(F.) To a fresh portion of the fluid add *Hydrate of Soda* and warm.

NO ODOUR OF AMMONIUM indicates the absence of this substance.

Evaporate a fresh portion to dryness, moisten a piece of platinum wire and dip it into the residue. Heat it in the flame of the lamp.

It COLOURS THE FLAME YELLOW, SODIUM.

It COLOURS THE FLAME VIOLET, POTASSIUM.

Section 69.

DETECTION OF METALS—COMPLEX COMPOUNDS.

To the solution if not already made acid by *Hydrochloric Acid*, add a few drops of this acid.

NO PRECIPITATE. Pass on to (G), for there is no SUBOXID OF MERCURY or SILVER present. And if Lead, only in small quantities.

A WHITE PRECIPITATE, CHLORIDS OF LEAD, SILVER and the SUB-CHLORID OF MERCURY. (If the solution was an alkaline one, this may be due to the separation of SILICIC ACID, TEROXID OF ANTIMONY, ARSENIUS ACID, or BORACIC ACID. The three latter are soluble in an excess of the acid, while the first may be detected by its gelatinous character, &c.)

Filter, keeping the filtrate for detection of other Metals, as under (G).

Wash the precipitate with hot water, adding the wash-water to the rest of the solution.

IT IS ALL DISSOLVED, probably LEAD.

IT IS NOT ALL DISSOLVED. Pour upon the precipitate upon the filter *Ammonia*.

IT IS ALL DISSOLVED, SILVER. EXAMINE the filtrate for this.

IT TURNS BLACK. SUBCHLORID OF MERCURY. Dissolve in strong Nitric Acid and test the solution as under Suboxid of Mercury. (The ammoniacal filtrate should be examined for Silver in all cases.)

(G.) To the filtrate from the Hydrochloric Acid precipitate, or the solution in which the Hydrochloric Acid failed to produce a precipitate, add *Hydrosulphuric Acid* until the fluid smells distinctly of it, and warm.

NO PRECIPITATE. Pass on to (K), for there are no metals of the fifth or sixth groups present.

A PRECIPITATE. Filter and wash, keeping the filtrate for further examination, as under (K).

To the precipitate upon the filter add *Sulphid of Ammonium*.

IT IS NOT DISSOLVED. Pass on to (H), for there are no metals of the sixth group present.

THE PRECIPITATE OR A PART OF IT IS DISSOLVED IN SULPHID OF AMMONIUM. (Ascertained by diluting a portion of the filtrate from the treatment with Sulphid of Ammonium, and adding dilute Hydrochloric Acid.)

Dilute the solution in Sulphid of Ammonium, add dilute *Hydrochloric Acid* to acid reaction, and warm. Filter and wash. To the precipitate upon the filter add *Carbonate of Ammonia*.

NONE OF THE PRECIPITATE IS DISSOLVED. (Ascertained by adding Hydrochloric Acid to the solution, and then Hydrosulphuric Acid.) Absence of ARSENIC.

A PORTION IS DISSOLVED, ARSENIC.

(a.) Wash, and dissolve the precipitate, if any remains undissolved in the Carbonate of Ammonia, in *Nitro-Hydrochloric Acid*. Evaporate until all the Nitric Acid, with all the free acid, has been driven off. Add then *Sulphate of Soda* and allow to stand.

NO PRECIPITATE. Pass on to (b), for there is no TIN present.

A WHITE PRECIPITATE, TIN. Filter and wash.

(b.) To the filtrate from *a* add crystals of Sulphate of Protoxid of Iron, and allow to stand for a short time in a warm place.

NO PRECIPITATE. Pass on to (c), for there is no GOLD present.

A BROWN PRECIPITATE, GOLD. Filter.

(c.) To the filtrate from (b), add *Hydrate of Soda* to alkaline reaction, and heat for a few minutes; then add *Hydrochloric Acid*, to acid reaction. All the precipitate dissolves. Pass on to (d), for there is no PLATINUM present.

A BLACK RESIDUE remains, undissolved PLATINUM. Filter.

(d.) To the filtrate from (c), or to the fluid in which there is no residue undissolved, add *Hydrosulphuric Acid*.

NO PRECIPITATE. Absence of ANTIMONY.

AN ORANGE-RED PRECIPITATE, ANTIMONY.

(H.) TREATMENT OF THE PORTION UNDISSOLVED IN SULPHID OF AMMONIUM.

To the precipitate remaining upon the filter undissolved in Sulphid of Ammonium, add strong *Nitric Acid* with *Hydrochloric Acid*, and evaporate the solution nearly to dryness. Dilute and add *dilute Sulphuric Acid*.

NO PRECIPITATE. Pass on to (e), for there is no LEAD present.

A WHITE PRECIPITATE, LEAD. Add the acid until there is no longer any precipitate, and filter.

(e.) To the filtrate from the Sulphate of Lead or the solu-

tion in which Sulphuric Acid has failed to produce a precipitate, add *Ammonia* until the fluid smells distinctly of it.

A PRECIPITATE IS FORMED, BISMUTH OR MERCURY.

Filter and wash with water, to which a few drops of *Ammonia* have been added.

THE FILTRATE IS COLOURLESS. Pass on to (f), for Copper is not present. (To be sure that there may not be a trace of Copper present, acidulate the filtrate with Hydrochloric Acid, and add Ferrocyanide of Potassium.)

THE FILTRATE IS COLOURED BLUE, COPPER.

(f.) Pour upon the precipitate remaining undissolved upon the filter, and which may be Teroxid of Bismuth or Protoxid of Mercury, or both, a few drops of *solution of Cyanid of Potassium*.

NONE IS DISSOLVED. (Ascertained by adding to the filtrate Hydrosulphuric Acid.) Absence of Protoxid of Mercury.

A PORTION OR ALL IS DISSOLVED, MERCURY. If any remains undissolved upon the filter, it must be TEROXID OF BISMUTH. Dissolve in Hydrochloric Acid, and test for this metal.

(K.) TREATMENT OF THE FLUID IN WHICH HYDROCHLORIC OR HYDROSULPHURIC ACID HAS PRODUCED NO PRECIPITATE, OR THE FILTRATE FROM THE PRECIPITATE.

To the fluid in which neither Hydrochloric Acid nor Hydrosulphuric Acid has produced a precipitate, or to the filtrate from these precipitates, add *Chlorid of Ammonium* and *Ammonia* until the fluid smells distinctly of the latter, and then no matter whether the *Ammonia* has pro-

duced a precipitate or not, add *Sulphid of Ammonium* and warm.

NO PRECIPITATE. Pass on to (L), for there are no members of the third and fourth groups present.

A PRECIPITATE. Filter and wash, saving the filtrate for testing for members of the first and second groups, as at (L).

Wash the precipitate with very dilute cold Hydrochloric Acid.

IT ALL DISSOLVES. Absence of NICKEL and COBALT. Pass on to (g).

THE WHOLE OR A PORTION REMAINS UNDISSOLVED as a black residue upon the filter, NICKEL, COBALT, or both. Dissolve in strong Nitric Acid, and add Ammonia in excess, and allow to stand in a warm place for twenty-four hours. All the NICKEL will be precipitated out, while the COBALT will remain in solution, giving a red-coloured fluid.

(g.) To the portion dissolved in Hydrochloric Acid add a few drops of strong *Nitric Acid*, and heat until all smell of *Hydrosulphuric Acid* has disappeared. Now add *Ammonia* to alkaline reaction, and then *Acetic Acid* to a very slight acid reaction, and heat to boiling.

NO PRECIPITATE. Pass on to (h), for there is no ALUMINUM or IRON present.

THE PRECIPITATE IS WHITE, ALUMINUM.

THE PRECIPITATE IS RED, IRON. (But Aluminum may be present, and in order to test for this, dissolve the precipitate in Hydrochloric Acid, and add to the solution an excess of Hydrate of Soda. Filter.

and to the filtrate add Chloride of Ammonium. A white precipitate upon warming indicates the presence of ALUMINUM.

The character of the IRON may be detected by testing the original solution as under Iron.

(*h*.) To the solution in which Ammonia and Acetic Acid have produced no precipitate, or to the filtrate from this precipitate, add more Acetic Acid and allow to cool. Now add Hydrosulphuric Acid.

NO PRECIPITATE. Absence of ZINC. Pass on to (*k*).

A WHITE PRECIPITATE indicates the presence of ZINC. Filter and treat the filter as under (*k*).

(*k*.) To the filtrate from (*h*), add *Ammonia* to alkaline reaction and then *Sulphid of Ammonium* and warm.

NO PRECIPITATE. Absence of MANGANESE and CHROMIUM.

A FLESH-COLOURED PRECIPITATE, MANGANESE.

A DIRTY GREEN PRECIPITATE, CHROMIUM.

If the presence of both these be suspected, dissolve the precipitate in Hydrochloric Acid, and nearly neutralize with Carbonate of Soda, and then to the cold solution add an excess of *Carbonate of Baryta*. Allow to stand for half an hour, stirring frequently. Filter, and to the filtrate add Ammonia and *Sulphid of Ammonium*.

NO PRECIPITATE, ABSENCE of Manganese.

A FLESH-COLOURED PRECIPITATE, Manganese.

Dissolve the Carbonate of Baryta undecomposed upon the filter, in Hydrochloric Acid, neutralize with Ammonia, and add *Sulphid of Ammonium*.

NO PRECIPITATE, absence of CHROMIUM.

A GREEN PRECIPITATE, CHROMIUM.

(L.) To the solution in which none of the preceding reagents have produced a precipitate or the filtrate from (k), add *Carbonate of Ammonia* and warm.

NO PRECIPITATE. Pass on to (I), as there is neither BARIUM, STRONTIUM, nor CALCIUM present.

A WHITE PRECIPITATE, BARIUM, STRONTIUM or CALCIUM.

Filter, and dissolve the precipitate in Hydrochloric Acid and add *Sulphate of Lime*.

NO PRECIPITATE, even after standing for some time.
Absence of BARIUM and STRONTIUM.

A white precipitate appearing only after the lapse of several minutes, STRONTIUM.

A white precipitate appearing immediately indicates presence of BARIUM.

To another portion of the same solution add Ammonia to alkaline reaction, and then *Oxalate of Ammonia*.
A white precipitate, CALCIUM.

(I.) To the fluid in which Carbonate of Ammonia has failed to produce a precipitate, add some Phosphate of Soda.

A WHITE PRECIPITATE, MAGNESIUM.

NO PRECIPITATE, absence of MAGNESIUM. Pass on to (m).

(m.) To a portion of the original solution, add *Hydrate of Soda* and boil.

No smell of AMMONIA is given off, absence of that body.

Evaporate another portion to dryness, and place a small portion on a piece of platinum wire, and heat it in the alcohol flame.

A YELLOW COLOUR, SODIUM.

A VIOLET COLOUR, POTASSIUM.

In case the colour is yellow, it will be well to look at the flame of the lamp through a cobalt blue glass.

A red flame, POTASSIUM.

The flame not seen, but only the heated wire, indicates absence of POTASSIUM.

Section 70.

DETECTION OF ACIDS.

COMPOUNDS SOLUBLE IN WATER.

Consider what acids form soluble compounds with the metals found in the previous sections.

ARSENIOUS and ARSENIC, CARBONIC, HYDRO-SULPHURIC, CHROMIC, and SILICIC ACIDS have already been detected, if present, during the examination for bases. See Section 68 or 69.

To a portion of the neutral solution add *Chlorid of Barium*.

NO PRECIPITATE.* Absence of SULPHURIC, PHOSPHORIC, CHROMIC, and SILICIC ACIDS, as well as notable quantities of BORACIC and HYDRO-FLUORIC ACIDS. Pass on to (A).

* If the solution contains a considerable quantity of an ammoniacal salt, the non-formation of a precipitate cannot be considered as conclusive evidence of the absence of these acids, since the Salts of Barium, with the exception of the Sulphate, are more or less soluble in water containing Ammoniacal Salts in solution.

A WHITE PRECIPITATE insoluble in Hydrochloric Acid.

If the precipitate is gelatinous, the acid may be Hydrofluoric ; if a white powder, Sulphuric. To a fresh portion of the fluid, add *Sulphate of Lime* ; if there is a precipitate it must be from the presence of FLUORINE. No precipitate indicates the presence of SULPHURIC ACID.

(A.) Neutralize a portion of the original solution and add a few drops of *Nitrate of Silver*.

NO PRECIPITATE indicates that there are no CHLORIDS, BROMIDS, IODIDS, CYANIDS, FERROCYANIDS, FERRICYANIDS or SULPHIDS, present ; and if the solution is nearly neutral, that all PHOSPHATES, ARSENITES, ARSENATES, CHROMATES, SILICATES and OXALATES are absent. In order to be sure that the last mentioned acids are not present, pass on to (B).

A PRECIPITATE IS FORMED. It may consist of any of the above-mentioned acids. Where there is only one acid present, the colour of the precipitate may indicate its constitution ;* but in the case of complex compounds, all the acids must be sought for.

Add to the fluid dilute *Nitric Acid*.

THE PRECIPITATE IS DISSOLVED. Pass on to (B), for neither CHLORINE, BROMINE, IODINE, CYANOGEN, FERROCYANOGEN, FERRICYANOGEN, nor SULPHUR, is present.

THE PRECIPITATE IS NOT DISSOLVED, or a portion remains undissolved. Filter and save the filtrate for

* Chlorid, Bromid, Cyanid and Ferrocyanid of Silver are white, as are the Oxalate, Silicate and Borate ; Iodid, Phosphate and Arsenit, are yellow ; Arsenate and Ferricyanid, brownish-red ; Chromate purplish-red, and the Sulphid is black.

examination, as under (B). The residue may consist of a CHLORID, BROMID, IODID, CYANID, FERRO- or FERRICYANID, and if black, of a SULPHID (detected in the preliminary examination).

- (1.) Acidulate a portion of the original solution with *Hydrochloric Acid*, and add a few drops of the *Sesquichlorid of Iron*.

A BLUE PRECIPITATE indicates the presence of a FERROCYANID.

THE LIQUID IS COLOURED BROWNISH-RED. A FERRICYANID is present. Test with a proto salt of Iron.

- (2.) CYANOGEN, if present, will have been detected in the preliminary examination.
- (3.) To detect the Chlorine, Bromine and Iodine when they occur together, add to a portion of the original solution a little *Sulphuric Acid*, then a solution of *Starch*, with a few drops of strong *Nitric Acid*. If IODINE is present, the liquid will be coloured BLUE. Now add *Chlorine water* drop by drop, and the solution, if BROMINE is present, will turn BROWN. A small portion of Ether, agitated with the fluid, will become a deep red, the liberated Bromine being dissolved in it. When the precipitate with the Nitrate of Silver insoluble in Nitric Acid, has been a considerable one, and only small quantities of Bromine and Iodine have been detected, there can be no doubt but that CHLORINE also is present.
- (3.) Or, if Iodine has been detected by the Starch solution, add to a fresh portion of the fluid an excess of a solution of the *Sulphate of the Protoxid of Iron*, and then *Sulphate of Copper* as long as there is a precipi-

tate. All the Iodine will be precipitated as the Sub-iodid of Copper. Filter and evaporate the filtrate to dryness. Now mix the residue with some Bichromate of Potassa; add strong Sulphuric Acid and heat, having first fitted the mouth of the test tube with a glass tube, to carry off the volatile products. A reddish vapour comes off which colours an Ammonia solution red CHLORINE.

The gas when passed into the Ammonia does not colour it BROMINE.

(B.) Solution in which *Chlorid of Barium* or *Nitrate of Silver* has failed to produce a precipitate insoluble in an Acid solution.

To a portion of the original fluid, or to the filtrate from (A), made as nearly neutral as possible, by the addition of Ammonia, add *Chlorid of Calcium*.

NO PRECIPITATE indicates that there is no Oxalic, Phosphoric, or Boracic acid present.* Pass on to (B).

A PRECIPITATE, insoluble in dilute *Acetic Acid*, indicates the presence of OXALIC ACID. If soluble in *Acetic Acid*, it may be PHOSPHORIC, BORACIC, or ARSENIC Acid. The latter, if present, has been detected in the examination for metals, and may be removed by Hydro-sulphuric Acid.

Acidulate a portion of the original solution after it has been concentrated with a few drops of *Hydrochloric Acid*, and dip into it a piece of *Turmeric paper*. If when this is dried, the moistened portion is turned brown, BORACIC ACID is present.

* If the solution is very dilute, the Boracic Acid may not be precipitated, and if not quite neutral, or slightly alkaline, there may be no precipitate of the Phosphoric Acid.

Add to a portion of the original solution, *Sulphate of Magnesia*, and *Ammonia*. A WHITE CRYSTALLINE PRECIPITATE indicates that PHOSPHORIC ACID is present.

(C.) The fluid in which neither *Chlorid of Barium*, *Nitrate of Silver*, nor *Chlorid of Calcium*, has produced a precipitate; or which has been filtered from these precipitates, may contain NITRIC, CHLORIC, or ACETIC Acids.

Test a portion with a *proto-salt of Iron*, for NITRIC ACID.

Evaporate a small portion to dryness, and add *Hydrochloric Acid*. Yellow fumes and the smell of Chlorine indicate the presence of CHLORIC ACID.

To another portion of the dry substance, add strong *Sulphuric Acid* and *Alcohol*. An etherial smell indicates the presence of ACETIC ACID.

If Silicic Acid has not been found, and its presence is suspected, add to the fluid an excess of *Hydrochloric Acid* evaporated to dryness. Dissolve up the residue in dilute *Nitric Acid*, and if a colourless, gritty, insoluble powder remains, it indicates the presence of SILICIC ACID.

CHROMATES are easily detected by the red colour of the solution, and the reaction with Hydrosulphuric Acid in the examination for the detection of metals.

Section 70.

DETECTION OF ACIDS.

COMPOUNDS INSOLUBLE IN WATER.

As all CHLORATES and NITRATES are soluble, these Acids cannot be present.

Dissolve the substance insoluble in water in *Nitric* or *Hydrochloric Acids*, and examine for Acids as under Sec. 70.

All SULPHIDS, CHROMATES, CHLORIDS, IODIDS, BROMIDS, FLUORIDS, FERRO and FERRICYANIDS, have been detected in the preliminary examination.

In case of an insoluble sulphate, or silicate, it can be fused with *Nitrate of Potassa*, *Carbonate of Soda*, and *Charcoal*, as in Sec. 67, and the solution examined for the SULPHURIC or SILICIC ACIDS.

